

# Reverse bias breakdown

- Reverse Breakdown
  - Zener Breakdown
  - Avalanche Breakdown

# Reverse bias breakdown

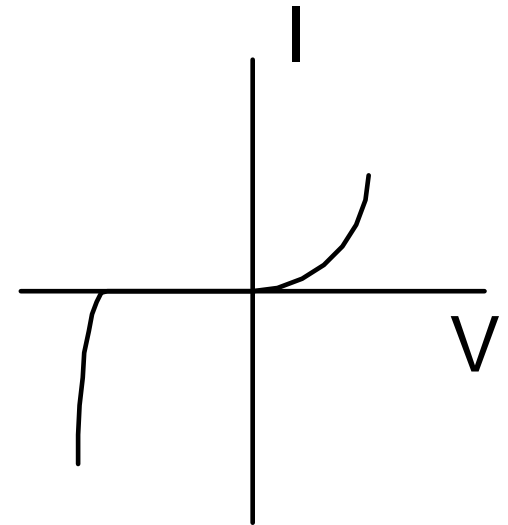
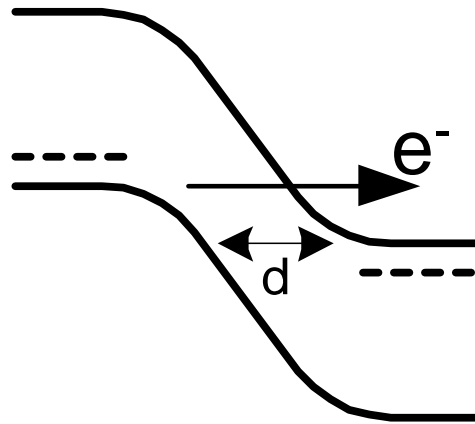
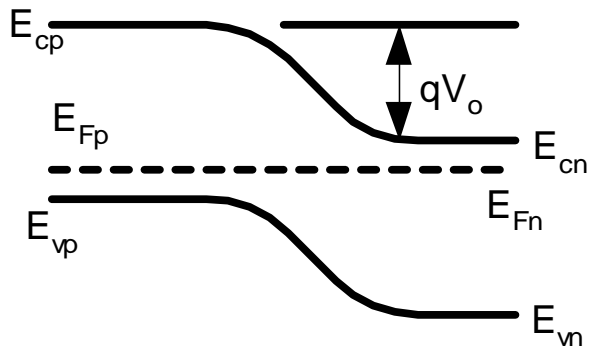
- Under reverse bias a pn junction exhibits a small voltage independent current until a critical voltage is reached  $V_{br}$ . If the bias voltage exceeds  $V_{br}$  the current increases dramatically.
- If biased properly with a current limiting diode, you can operate in reverse breakdown mode without damaging the diode.

# Reverse Breakdown

- Zener Breakdown
  - This effect applies to heavily doped junctions (p+, n+). This is a low voltage effect.
  - Barrier is thin due to high abrupt doping
  - When the reverse bias voltage is large enough, electrons can tunnel to the p-side, and holes can tunnel to the n-side (section 2.4.4)
  - Reverse bias of a p+/n+ junction
    - leads to large electric field ( $10^6\text{V/cm}$ )
    - leads to covalent electrons being “ripped away”

# Reverse Breakdown

- Zener Breakdown

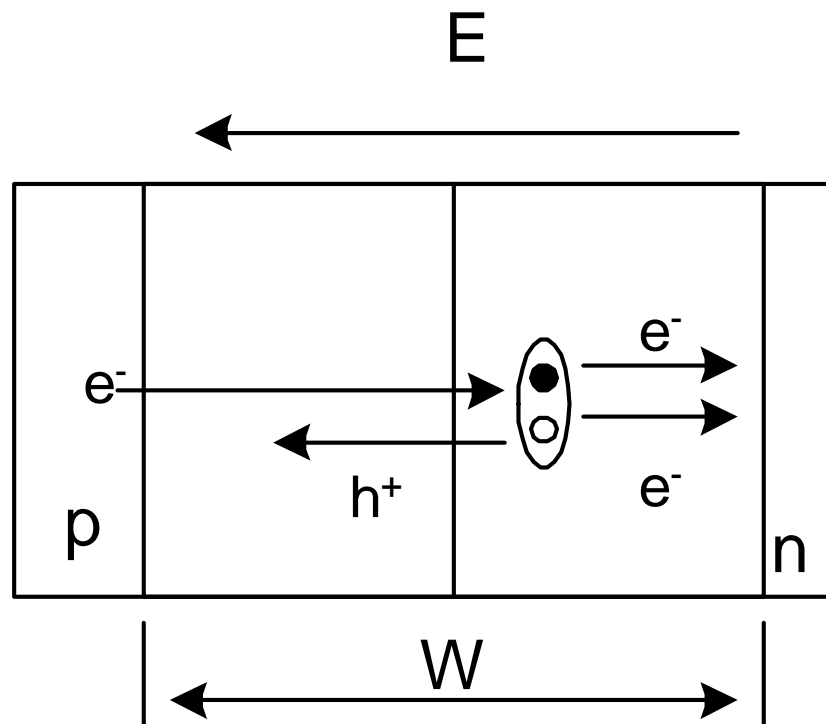


# Reverse Breakdown

- Avalanche Breakdown
  - Lightly doped junctions, tunneling can not occur
    - $W$  increases with reverse bias.
  - Impact ionization
    - A carrier can be accelerated by a high electric field with enough kinetic energy to knock an electron out of the lattices covalent bond and make an EHP. One carrier can cause many carriers to be created.
    - To design  $V_{br}$ , use figure from text

# Reverse Breakdown

- Avalanche Breakdown



# PE

An abrupt p-n junction has the following properties at 300K:

p side	n side
$N_a=2 \times 10^{20} \text{cm}^{-3}$	$N_d=1 \times 10^{15} \text{cm}^{-3}$
$\tau_n=.1 \times 10^{-6} \text{s}$	$\tau_p=10 \times 10^{-6} \text{s}$
$\mu_p=200 \text{ cm}^2/\text{Vs}$	$\mu_n=1300 \text{ cm}^2/\text{Vs}$
$\mu_n=700$	$\mu_p=450$
$A=10^{-4} \text{ cm}^2$	$A=10^{-4} \text{ cm}^2$

Find the breakdown voltage if the diode is made of Ge.

Find the breakdown voltage if the diode is made of Si, and

$N_d$  is changed to  $1 \times 10^{19} \text{ cm}^{-3}$ .